influence of the actual cost of transporting a given weight varies greatly. Some railway officials say that it is a negligible figure and do not consider that a few hundred pounds more or less on the car affects the cost of operation; while others figure that it costs 30 cents per year to carry an extra pound. The generally accepted figure of five cents per pound per year has a good deal of justification. However, the only tangible figure is that for power. All other elements entering into consideration are more indefinite. Recently an analysis of the service of a large city line where the maximum schedule speeds are operated showed the power consumption at the power house to be 170 watt-hours per ton-mile, and the average miles for a car owned is 40,000 per year. Current costs this company 0.7 cent per kilowatt-hour. It can, therefore, be seen that for current alone the cost of hauling one pound per year is 2.38 cents. There are of course other expenses that increase with weight, such as larger investment for power supply, feeders and extra cost of the maintenance of right of way, due to the increased weight to be carried.

When considering power alone, savings can be made almost in proportion to reduction in weights of cars.

When the successful storage battery cars were put in operation, a great object lesson in car body and truck construction and electrical design was given to the equipment designers in this country.

One of the next steps was the realization that two-motor equipments will give satisfactory service where grades do not exceed five per cent and where trailer operation is not required. However, there are many American cities where grades exceed five per cent, where two-motor equipments are far from satisfactory.

One of the next greatest advances was made by Mr. P. N. Jones and his assistants when they put 24-inch wheel equipments in service on the Pittsburgh railways. With these cars and other cars of this character which have since been built, the weight per seated passenger was decreased to approximately 600 pounds, while the preceding types of cars using four-motor equipments had a weight equal to 900 or 1,000 pounds per seated passenger. With the small diameter of wheel smaller truck strains are obtained, which coupled with the less weight of wheel gives us trucks which are roughly speaking 33⅓ per cent lighter than the trucks which were formerly used for this same class of service. Since the Pittsburgh railways put in service cars with 24-inch wheels, a number of other companies have also purchased the same class of equipment, and all indications now are that an entirely new field of development has been started by the small diameter of wheel. With single truck cars it is possible to have a much longer wheel base with no greater binding in curves than is obtained with a relatively short wheel base with a large diameter of wheel.

Recently the jitney competition has caused operators to again review general car designs to determine if it is feasible to develop a light weight one-man car. Mr. J. M. Boseubury, Superintendent of Motive Power of the Illinois Traction System, has designed a single-end and double-end one-man car; each of these cars seating 30 passengers. The single-end car completely equipped will weigh 10,000 pounds, and the double-end car 15,000 pounds. These weights are equal to 333 and 500 pounds, respectively, per seated passenger.

Mr. C. O. Birney of the Stone & Webster Engineering Corporation has designed a single-end one-man car which will weigh completely equipped 9,000 pounds and seat 29 passengers, which is equal to 310 pounds per seated passenger.

In some cases these types of cars might advantageously use motors smaller than we are now considering standard for railway service, but if there is a real demand for this class of car, and if it is ultimately believed by the transportation interests that such a car is desirable, the manufacturers of apparatus can be depended upon to supply equipments which will meet the requirements in every respect.

Again referring to the census figures, the next item which we have to consider is 8.17 per cent for maintenance of way and structures. Of course, with very light cars this figure will be reduced, but as the amount of the reduction is difficult of determination, a direct answer could not be given to this question, as it would vary greatly with different localities and different conditions.

The next figure from the census report is 7.06 per cent for maintenance of equipment. The maintenance figure would be reduced with the small light weight cars from 10 to 20 per cent.

All that have been discussed previously in this paper have been features which enter into the design of our present cars and those things which may be considered when designing the small one-man car. From a purely engineering standpoint there is not the slightest doubt but that the small light weight one-man car should be used for practically all service. With the small car when compared to larger cars used at present practically the same service can be given with at least 18 per cent less expense; that is, when operating a one-man car and in giving service that is required in many cases.

For a direct comparison of power, with different number of stops per mile and different car weights, a curve

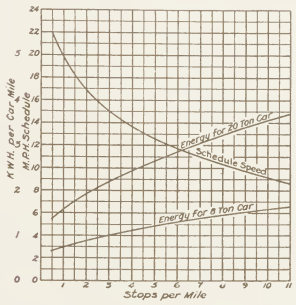

Fig. 3. Curves showing Energy Saving with Light Cars for Various Stops
Free speed 25 m.p.h.
Four-motor, 20-ton car—friction 24 lb. per ton
Two-motor, 8-ton car—friction 30 lb. per ton

showing the energy for an 8-ton and a 20-ton car is shown in Fig. 3. The 20-ton car includes the live load and therefore a four-motor equipment is favoring the larger car to a considerable extent, while the 8-ton car is showing the small one-man car up in as unfavorable a light as could be consistent insofar as power calculations are concerned. In order to help arrive at an understanding of the advantages and disadvantages of a one-man car, an example has been taken of a line which is 10.6 miles per round trip; the running time for the round trip one hour, with six stops per mile. Platform wages for the two-man car are taken at 50 cents per hour, for the one-man car 30 cents per hour, and the power is assumed to cost one and one-half cents per kilowatt-hour delivered to the car. The present cars seat 48 passengers and the proposed one-man car seats 32 passengers. The power as shown by the curve for a 20-ton car for this service would be 2.9 kilowatt-hours per car mile at the car, and for the 8-ton car 1.3 kilowatt hour. The receipts for the present cars are assumed to be 24 cents per car mile.

For the one-man car two grades of service are analyzed, viz.: one in which the headway during the non-rush hour is decreased from the present service of ten minutes to six minutes, and the second in which the interval between cars is left the same as at present, but giving during the rush hours an increased service the same as would be required with the one-man car frequent service.

The above analysis shows the receipts the same for all classes of cars. The smaller cars in both cases give much more frequent service, and it is but natural with this increased service that the receipts should be greater. With the large car the operating ratio of expense to gross receipts is 56.5 per cent, while with the small one-man car with cars at six-minute intervals instead of ten-minute service, the operating ratio is 53.5 per cent.

Reviewing the figures of the one-man car giving ten-minute service during the non-rush hours and three-minute service during the rush hours brings out several very prominent facts. The first is that the operating ratio has decreased to 46 per cent. The second is that with this type car more seats per hour can be furnished during the rush hour with 18 per cent decreased expense. Another fact is that during the non-rush hours the larger seating capacity of the larger cars is not required. In many cities the average load does not require more than 50 per cent of the seating capacity furnished. With the small cars the seating capacity during the non-rush hours is in the proportion to the logical actual requirements and conforms to a natural and proper saving.

It will be noted that expenses for traffic other than platform wages are left the same for the one-man car as for the proposed car as it would hardly seem fair to the small car to do otherwise. It is also assumed that the extra car miles which are made by the small car will offset any savings in maintenance of equipment and track, and the same proportions of expense have been used as have been found by the average throughout the country.

Certainly it would seem from these figures that in the future many light weight one-man cars will be purchased.

In many cities there are ordinances or rulings of public service commissions which at present prohibit the use of one-man cars, but it is reasonable to assume that when the case is properly presented, and if the light weight car will serve the needs of a community, these restrictions will be removed.

	Present Car Seating 48	Proposed One-man Car Seating 32	Proposed One-man Car Seating 32
Headway for 14 hours	10 min.	6 min.	10 min.
Headway for 4 hours	5 min.	3 min.	3 min.
Running time	60 min.	60 min.	60 min.
Cars required 14 hours	6	10	6
Cars required 4 hours	12	20	20
Seats per hour 14 hours	288	320	192
Seats per hour 4 hours	576	640	640
Car miles per day	1399.2	2332	1738.4
Power	$40.57	$30.31	$22.60
Platform wages	66.00	66.00	49.20
Maintenance of way 8.17 per cent	27.43	27.43	27.43
Maintenance of equipment 7.06 per cent	23.69	23.69	23.69
General expense 9.53 per cent	32.00	32.00	32.00
Total expense	$189.69	$179.43	$154.92
Receipts at 24 cents per car mile	335.80	335.80	335.80
Ratio of expense to gross receipts, per cent	56.5	53.5	46

Explosibility of Mixtures of Natural Gas and Air

THE Bureau of Mines has determined the explosive limits of mixtures of air and the natural gas used in Pittsburgh, this gas being typical of that supplied to many cities. For most practical purposes these limits may be accepted as applying quite closely to practically all the natural gas mentioned in this paper.

The limits were determined in a Hempel explosion pipette over mercury. Ignition was brought about from above by means of a small electric spark from an induction coil, driven by four dry cells. The smallest quantity of natural gas in a mixture of natural gas and air that upon ignition completely inflamed as observed by the eye was 4.92 per cent. The largest proportion was 14.50 per cent. In its determinations of explosive limits of methane-air mixtures the Bureau of Mines has found that large containers (430 liters capacity) and ignition from below with a large electric flash give wider limits than a small vessel and ignition from the top. In the case of methane-air mixtures the difference on the low limit was 0.5 per cent, this is probably true of natural gas-air mixtures; in other words, instead of 4.92 per cent natural gas being the low limit, under other conditions the limit may be as low as 4.50 per cent. The upper limit is undoubtedly extended as much.

For most of the samples the amount of air required for complete combustion varies but little. One cubic foot of pure methane requires 9.5 cubic feet of air; 1 cubic foot of the natural gas used in Pittsburgh requires 10 cubic feet of air.—*Technical Paper 109, Bureau of Mines.*

Electro-Photography of Coins or Medals

ACCORDING to *Electrotech. u. Maschinenbau*, photographic negatives of coins, or similar objects, can be readily obtained by the following method: An ordinary photographic plate is placed film side up on a sheet of metal; the object to be photographed is then placed in contact with the emulsion. Wires from the poles of a high-tension transformer giving a minimum p.d. of 5,000 volts are connected with the coin and metal plate, respectively. The explanation of the results obtained appears to be that a glow discharge occurs between the two metallic disks, which are separated by the glass of the photographic plate, and that the generation of ultra-violet rays accompanies this discharge. These rays decompose the silver bromide. Those parts nearest are subjected to strongest action, and *vice versa*, hence a half-tone image results.